Architecture & Town Planning

Lecture 5A: Sustainable/ Efficient Buildings

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Principles of Green Building

1. **Energy Efficiency** (Through Natural Lighting, Heating and Cooling. Natural cooling can be achieved through natural ventilation. Natural Lighting and heating can be achieved through building orientation and using insulation materials etc.)
2. **Water Efficiency** (By using water efficient faucets, Grey water treatment & Rain water harvesting for water reuse)
3. **Material Efficiency** (To use Recycled materials or local materials, Reducing Usage of Non-renewable Resources)
4. **Indoor Air Quality** (Avoiding use of Materials with pollutant content such as paint, water proofing materials etc., Humidity Control, Air Sanitization, Natural Ventilation)
5. **Waste Reduction** (Presence of Garbage Bins and Garbage Chutes in a building, waste separation and storage facilities on site)
6. **Operation and Maintenance optimization**

Active and Passive Techniques

Similar design strategies i.e. both are constructed to use as little energy as possible.

Active Design strategies

- Use purchased energy like electricity to keep the building comfortable. These strategies include forced-air **HVAC systems**, **heat pumps,** electric lights.

- It rely on external energy sources – or mechanical devices, such as **radiators, fans** and heat pumps which transport the heat or cold to the required spaces.

- **PV Panels** converts sunrays to electricity

- **Solar collectors** are used to convert sun's energy into useful heat for hot water or space heating

Passive Design strategies

- **Passive home design** takes advantage of climatic and site conditions to provide heating in the winter and cooling in the summer.
- It relies upon the design of the building itself to ensure climate control.
- Use ambient energy sources instead of purchased energy like electricity or natural gas. These strategies include day lighting, natural ventilation, and solar energy.
- Such as in sunrooms, solar energy captures sunbeams through glass windows that absorb and retain heat.

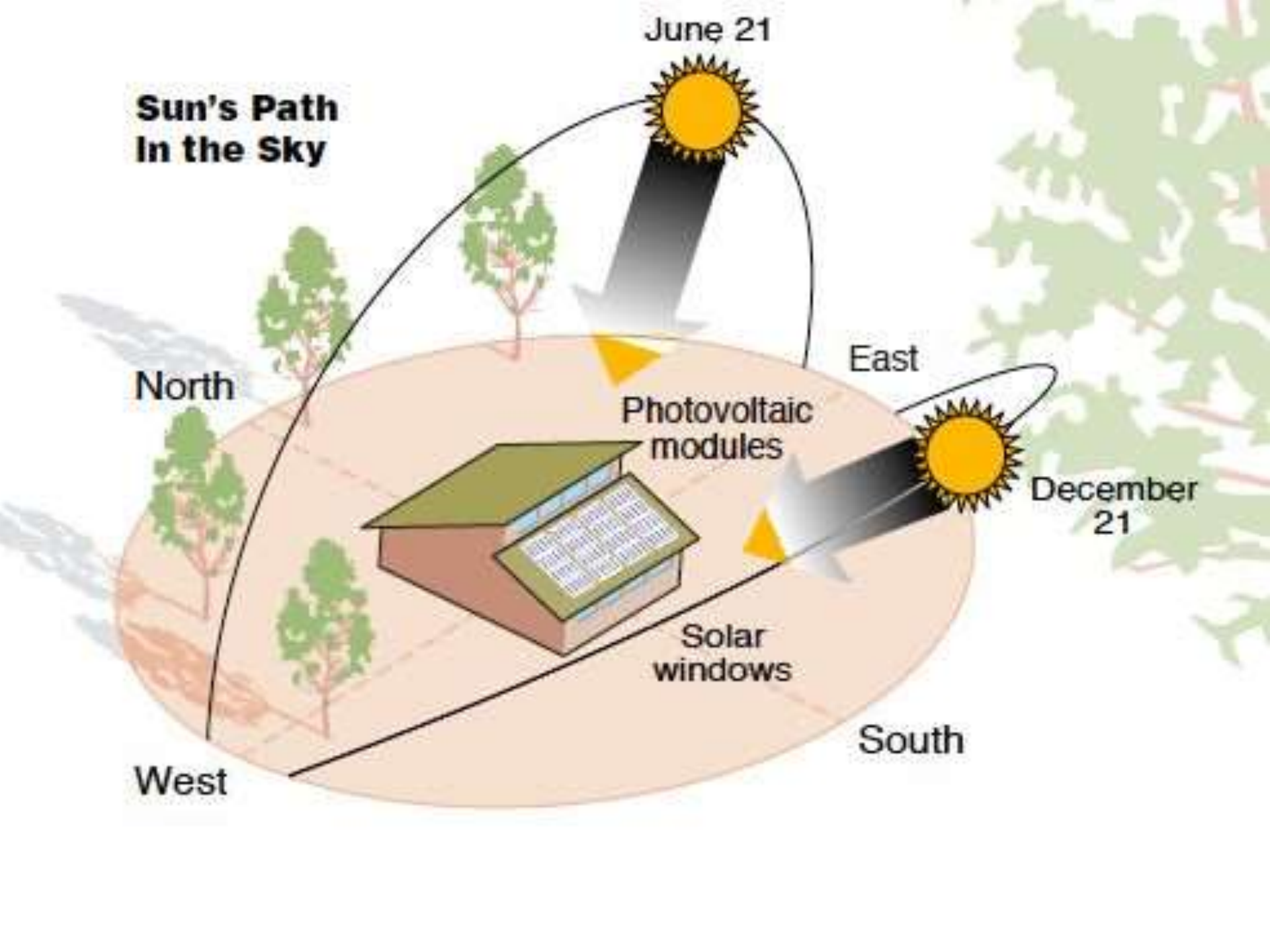
Energy Efficiency

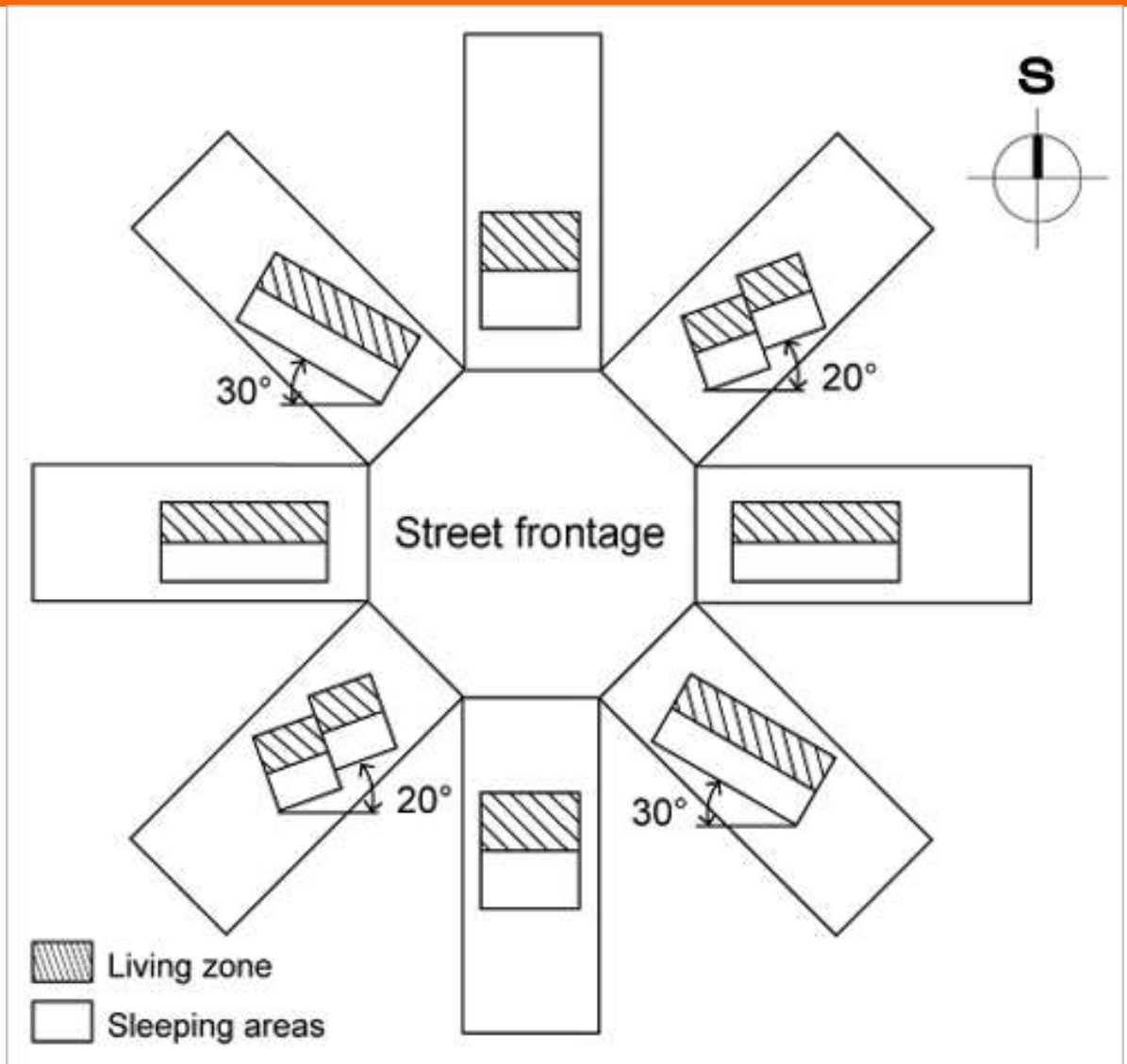
Methods to achieve Energy Efficiency in a Building

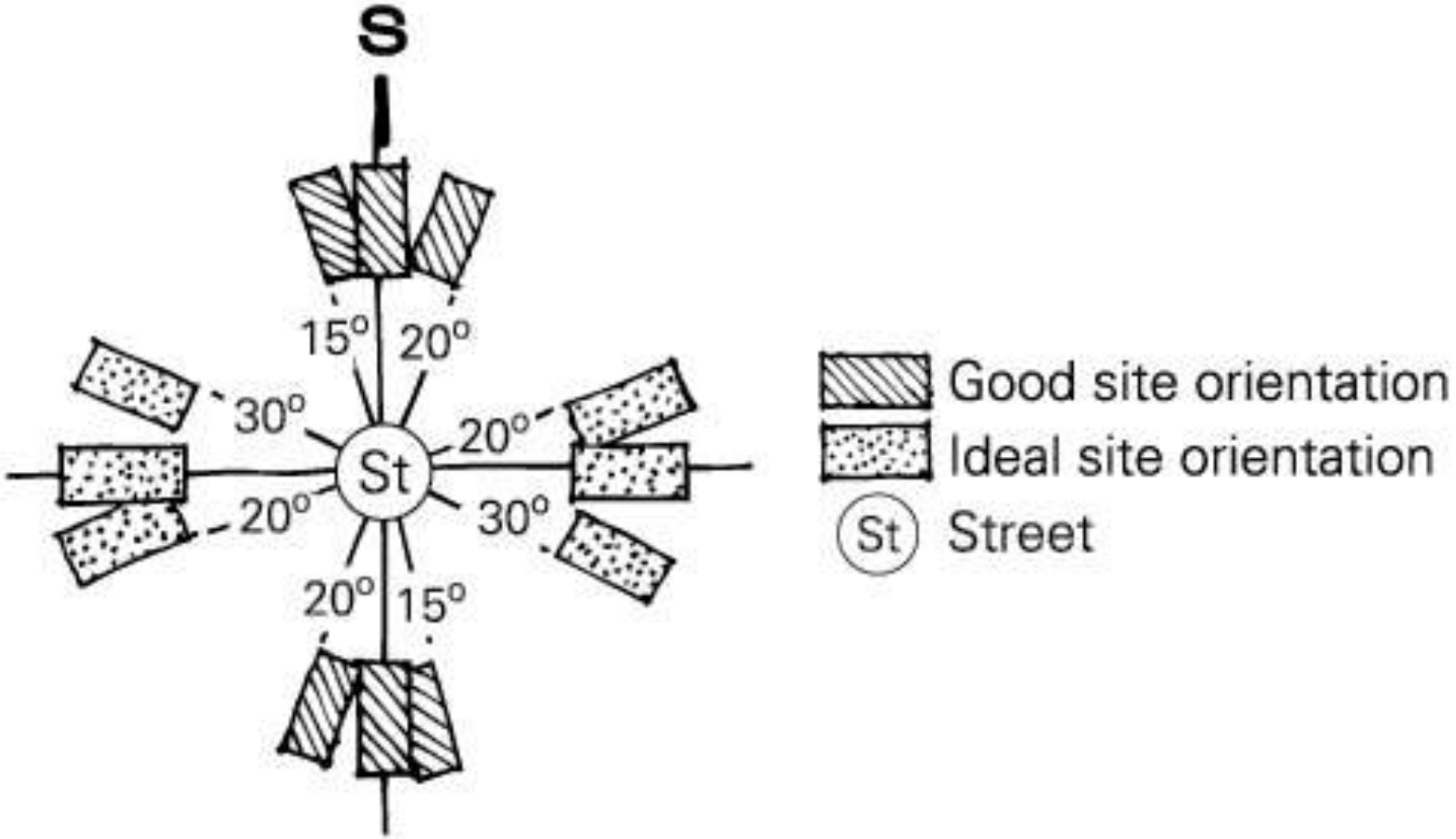
Passive Solar Heating

1. Orientation for Passive Heating

- Orientation is the positioning of a building in relation to seasonal variations in the sun's path as well as prevailing wind patterns
- Living areas and rooms you spend lots of time in should be south-facing to catch sun and light for the longest part of the day
- Bedrooms should be positioned on the northern side so they are cooler and more pleasant to sleep in at night
- South-facing walls and windows receive more solar radiation in winter than in summer
- Prefer Longer south & North Facing walls & Windows


Sun's Path
In the Sky
June 21
East
North
Photovoltaic
modules
December
21
Solar
windows
South
West

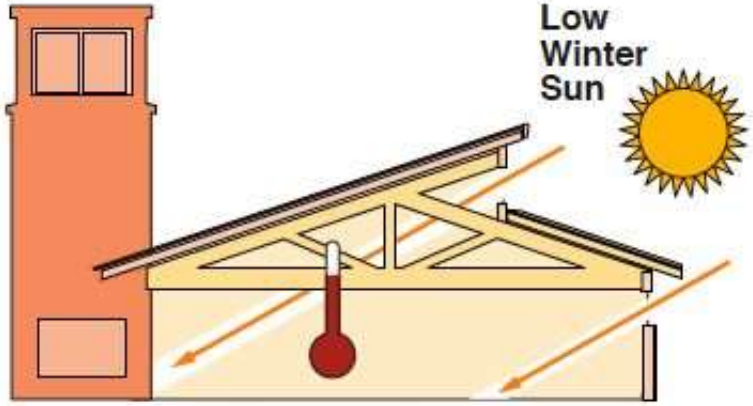

S
30°
20°
Street frontage
20°
30°
Living zone
Sleeping areas


S
15°
20°
30°
20°
St
20°
30°
20°
15°
Good site orientation
Ideal site orientation
St
Street

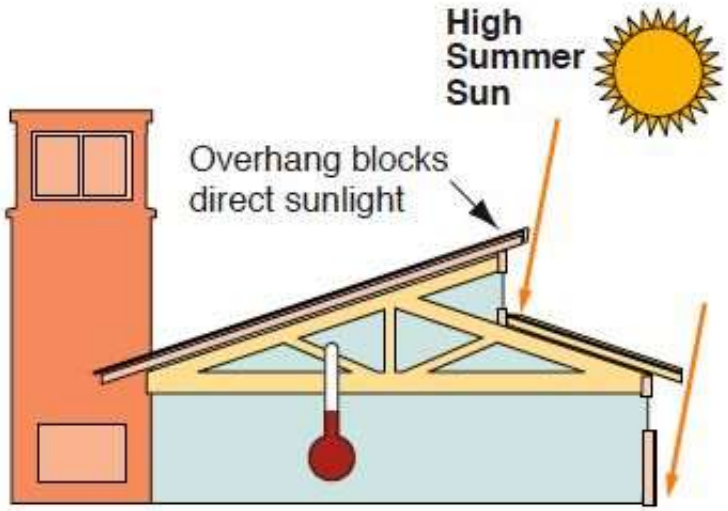
Orientation for Passive Heating

- For best passive heating performance, daytime living areas should face south. Ideal orientation is true south but orientations of up to 20° west of south and 30° east of south still allow good passive sun control

- Ideally, sunlight should not enter a home too much when the sun is at its highest but be allowed to enter when its at its lowest i.e. during the morning and in winter.



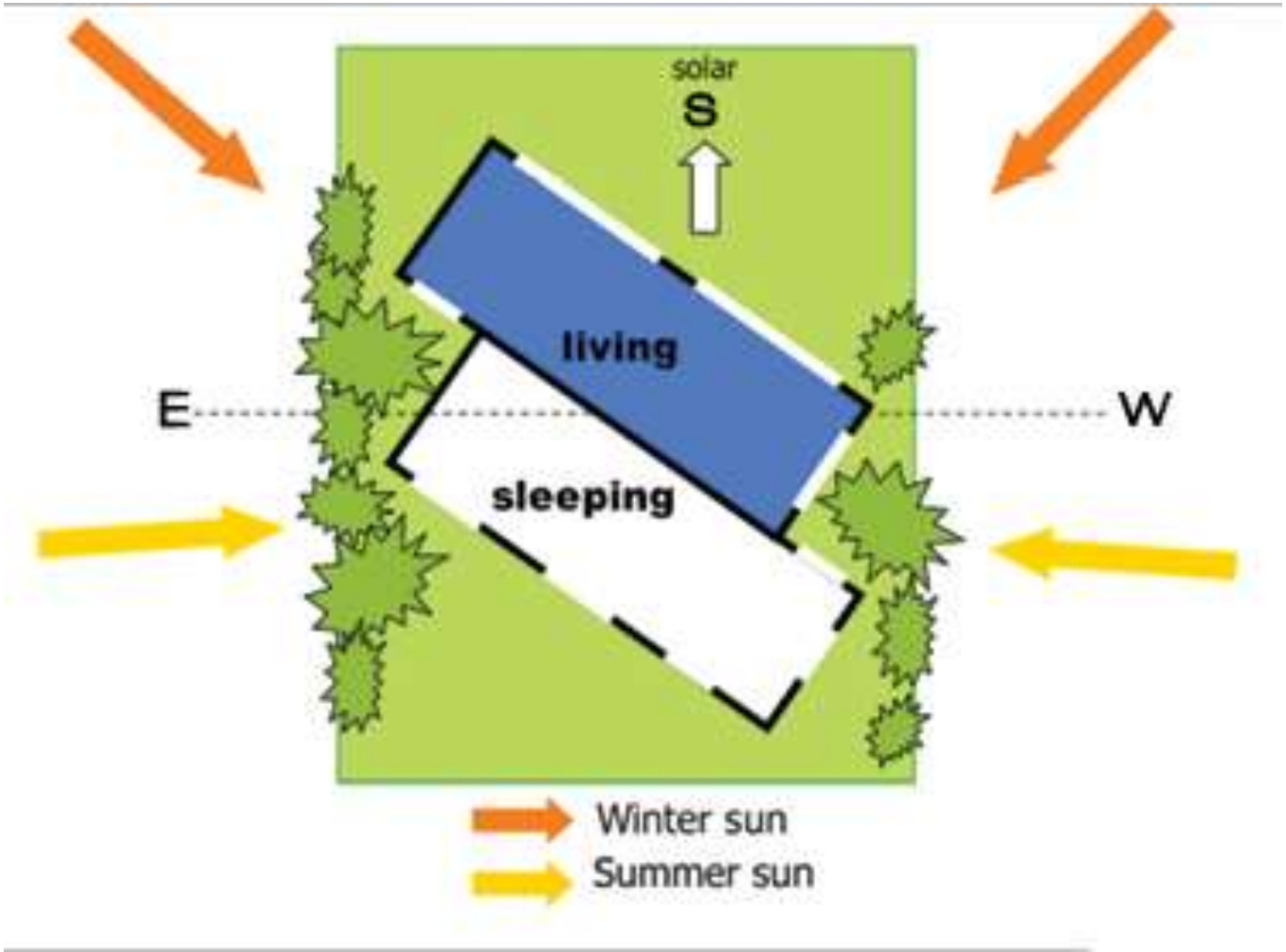
South windows accept direct sunlight to light and warm the building interior



- Surfaces facing South-East or South-West receive 10% less solar energy during the year than surfaces facing South.
- Surfaces facing North are in the shade all year round. North-East and North-West receives very little sun except at the peak of summer.
- Provide insulation and minimize glazing on north side of a house.
- Avoid West facing glass. Shade the windows and walls particularly west facing
- 10 % of Floor Area should be Windows for natural Lighting.
- 5 – 10 % floor area should be fully operable windows for natural ventilation.

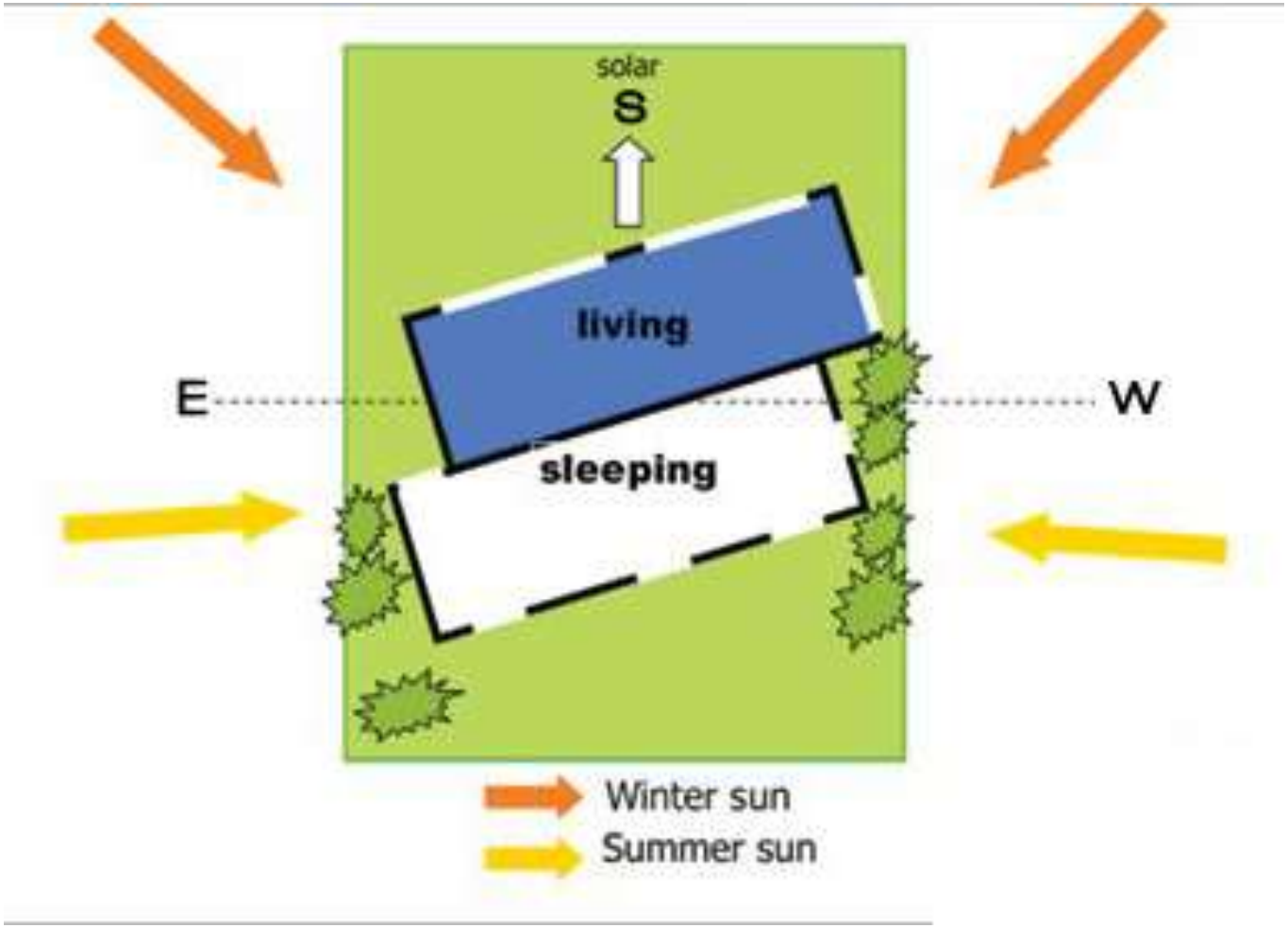
Cool or cold climate orientation — heating dominant

Up to 15 degrees West of Solar South



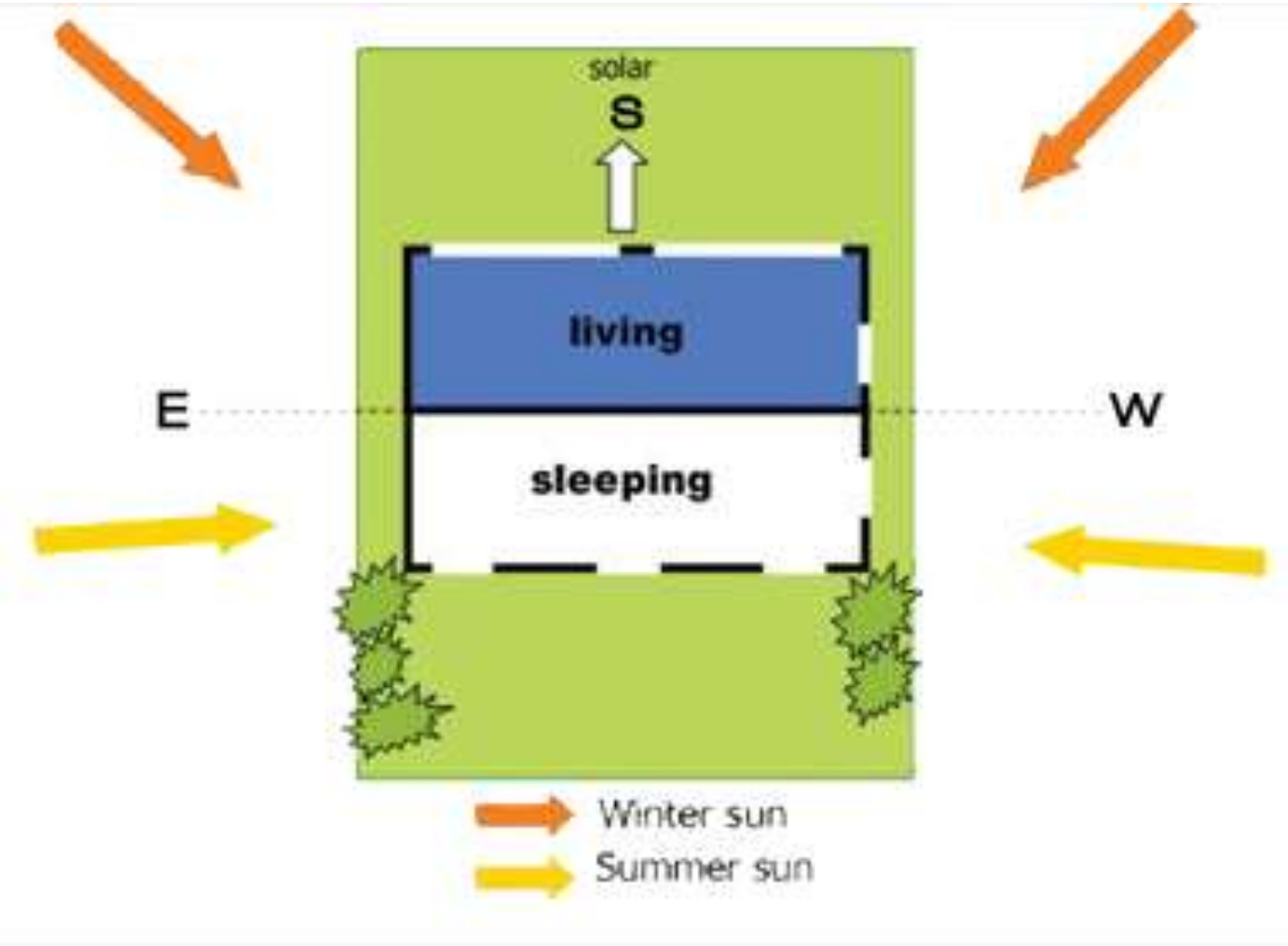
Mixed climate orientation — cooling dominant

Up to 30 degrees East of Solar South



Temperate climate orientation — daytime heating and cool sleeping required

Solar South



Hot humid orientation

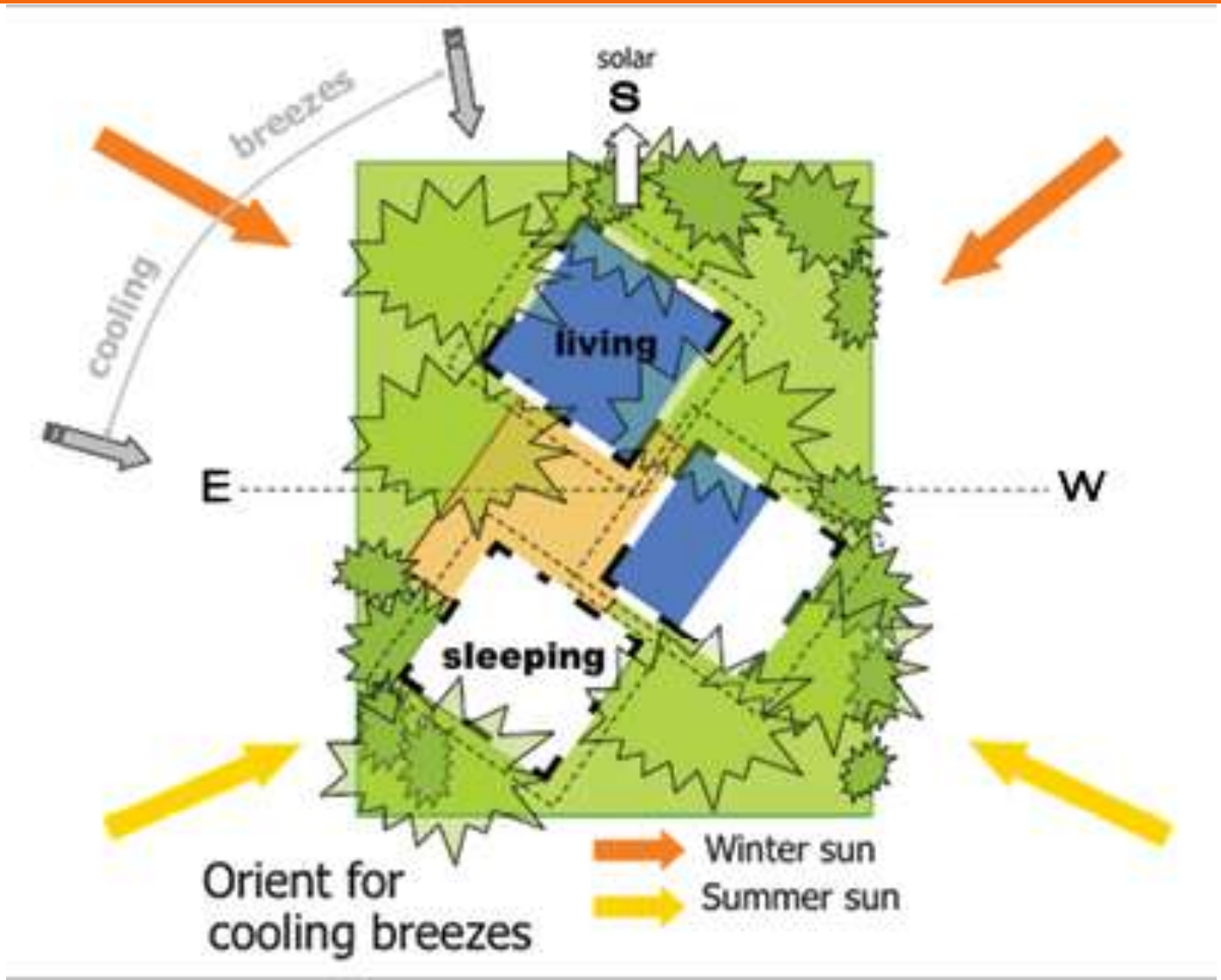
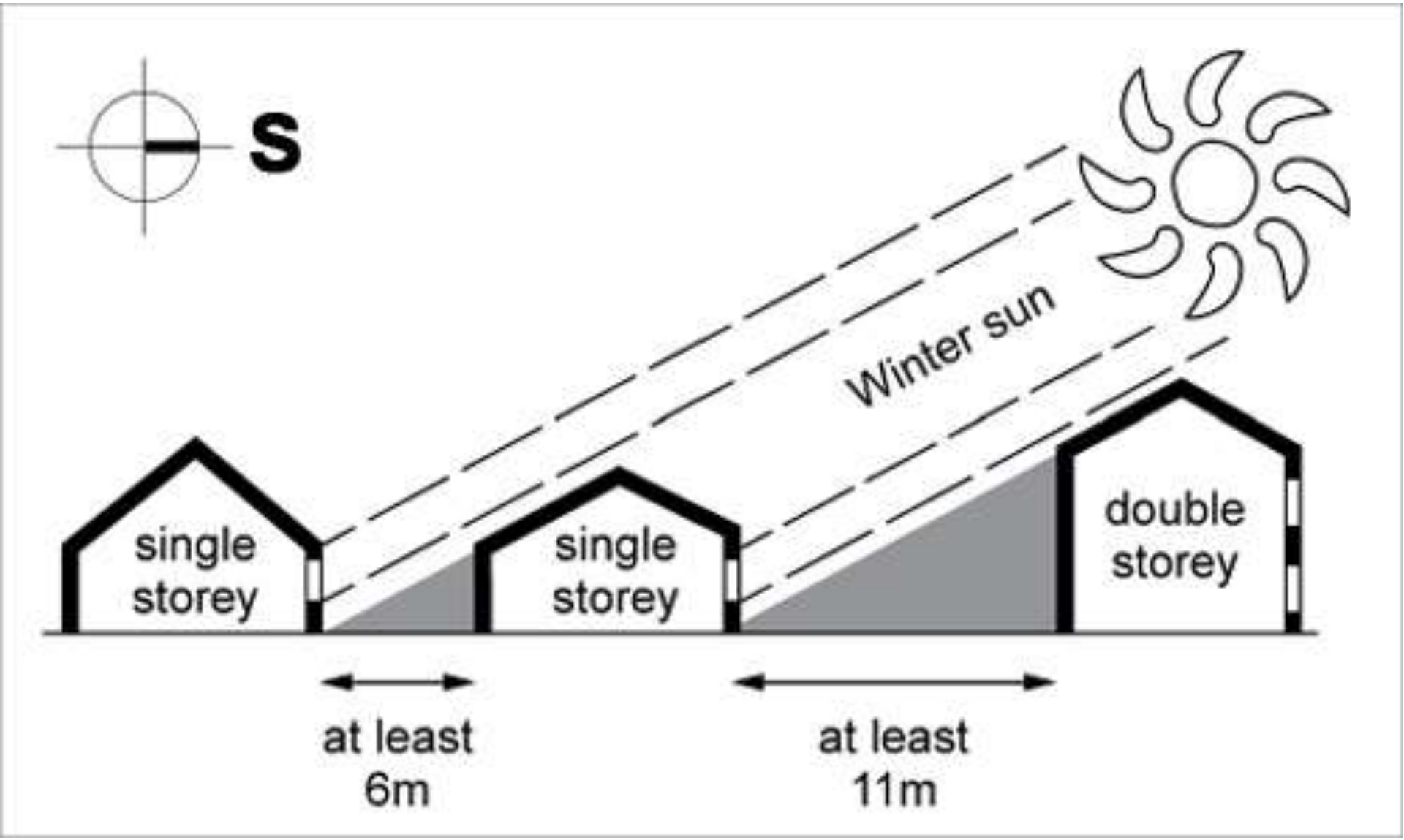


TABLE 21a

Suggested room orientations

	N	NE	E	SE	S	SW	W	NW
Bedroom*	●	●	●	●	●			
Bath*	●	●	●	●	●	●	●	●
Kitchen			●	●	●			
Dining			●	●	●	●		
Living				●	●			
Family				●	●	●		
Utility / Laundry*	●	●						●
Workshop*	●	●						●
Storage*	●						●	●
Garage*	●					●	●	●
Sun porch				●	●	●		
Outdoor space*			●	●	●	●		

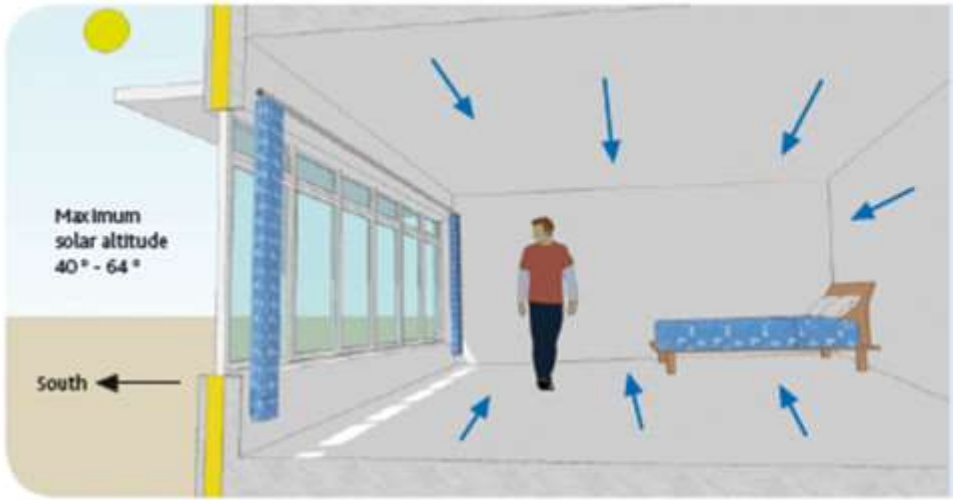
*The most suitable location of those indicated will depend on local climate — whether largely too hot or too cold, direction of winter winds and summer breezes, etc.


S
Winter sun
single storey
single storey
double storey
at least 6m
at least 11m

2. Thermal mass

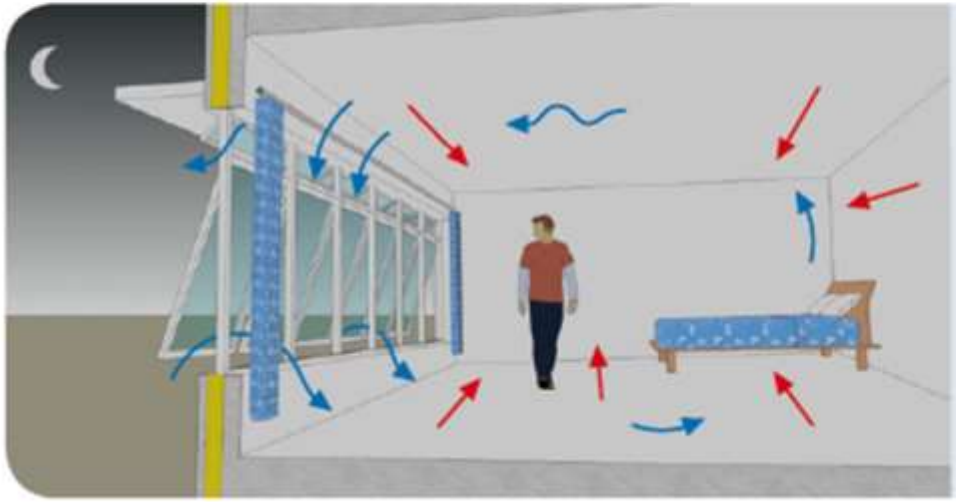
- A thermal mass is any material that is capable of **absorbing, storing and emitting solar heat.**
- The mass can **absorb heat from the sun during the day** and emit heat back into the room when the air temperature cools during the evening.
- A thermal mass is typically he**avy, dense and dark.**
- Examples: concrete, brick, sandstone.
- Thermal mass must be **externally insulated** (so the stored heat is not lost) and **internally exposed** (so solar heat can flow easily into the material) to offset heat loss to colder night-time temperatures

Thermal Mass in Summer



Summer day

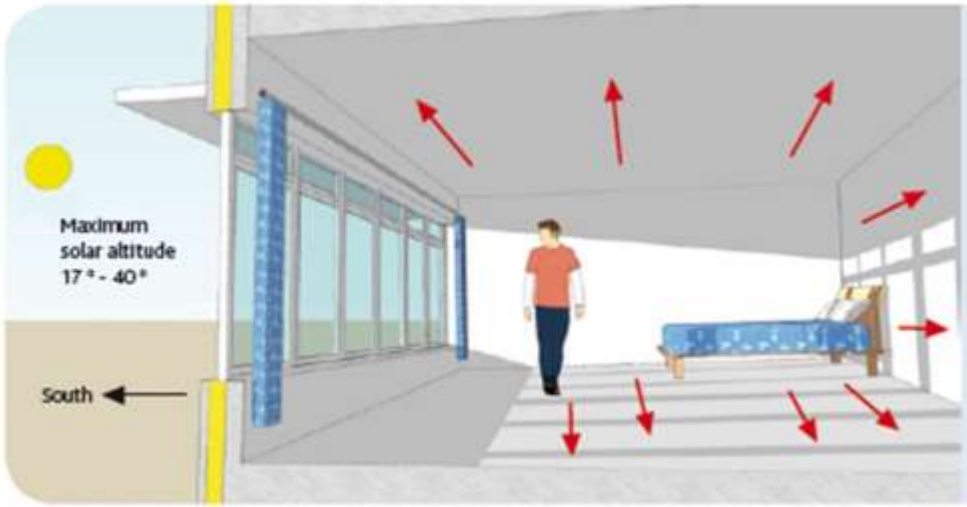
- During very hot weather, windows are kept shut to keep out the warm air.
- Overhangs on the south elevation can be used to keep out the high angle sun during the hottest part of the day.
- Cooling is provided by thermal mass in the floor and walls.



Summer night

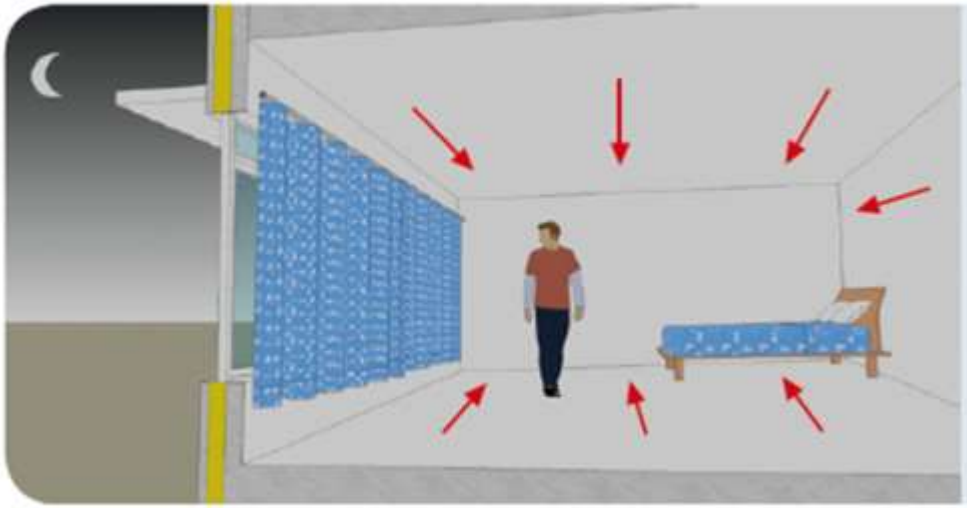
- The windows are opened at night to ventilate the building and cool the fabric.
- If another hot day is expected, the windows are closed again in the morning and the cycle is repeated.

Thermal Mass in Winter



Winter day

- During the heating season, the low angle sun can shine through south facing windows, and the heat is absorbed by thermal mass in the floor and walls.
- In the evening when the sun goes down and the temperature drops, the heat flow is reversed and passes back into the room.



Winter night

- At night, curtains are drawn and windows kept shut to minimise heat loss.
- Heat continues to be released by the thermal mass and supplementary heating is adjusted so only the minimal amount is used.
- By morning the thermal mass will have given up most of its heat and the occupants will typically have to rely on supplementary heating until later in the day.

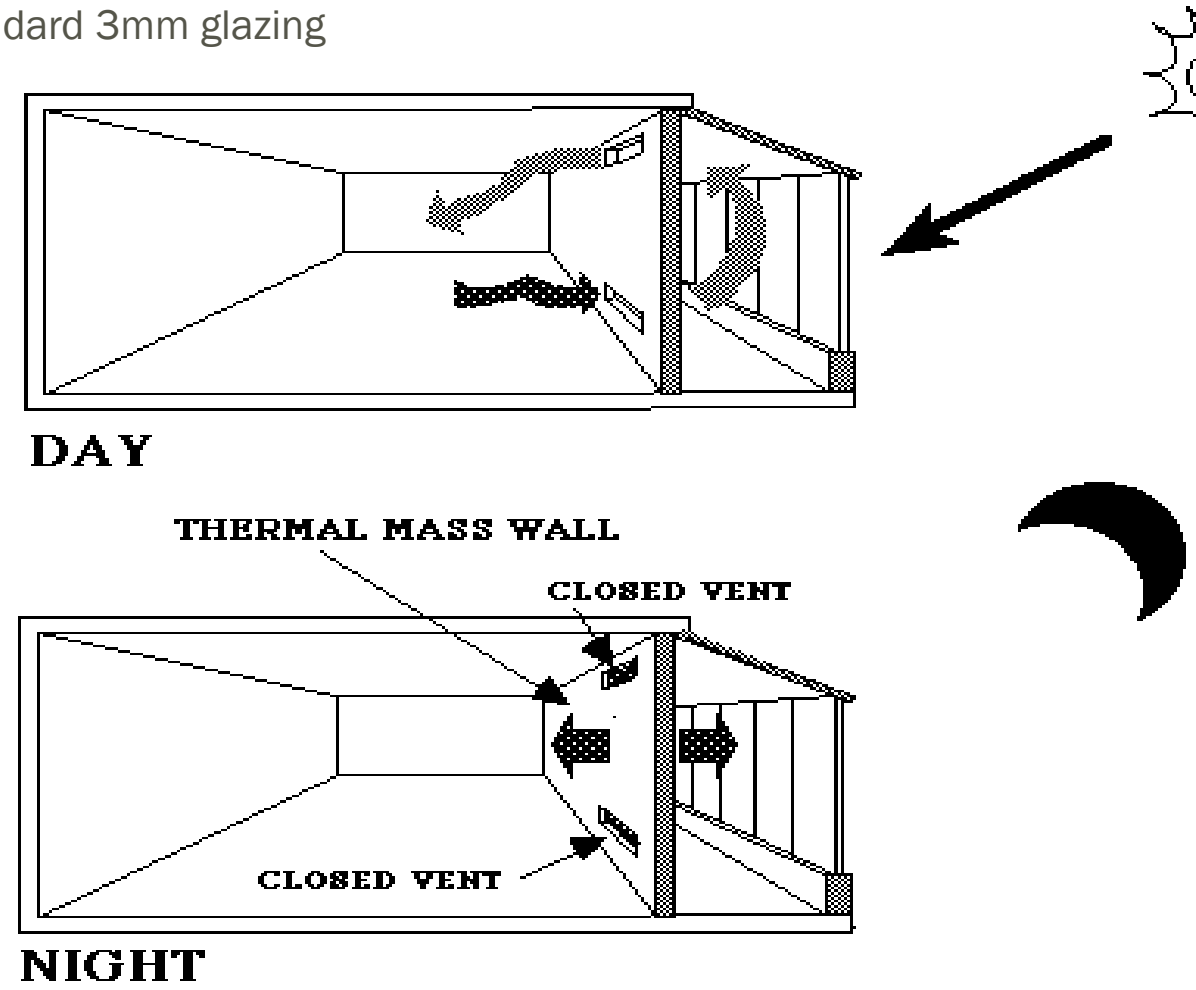
Disadvantages of Thermal Mass

- **In summer**, thermal mass is only beneficial if night time ventilation can be used to cool it down. Local issues such as, pollution and security concerns can sometimes make this impracticable

- **In winter**, older buildings with low levels of insulation and poor airtightness often required a relatively long pre-heat period to warm up the fabric

3. Greenhouse (Sun Space)

The greenhouse collects heat due to its solar exposure. This heat can be conducted through a thermal storage wall separating house and greenhouse. Figure shows Solar heat gain through standard 3mm glazing



4. Glass to Mass Ratio

- The area of South-facing glass with solar access:

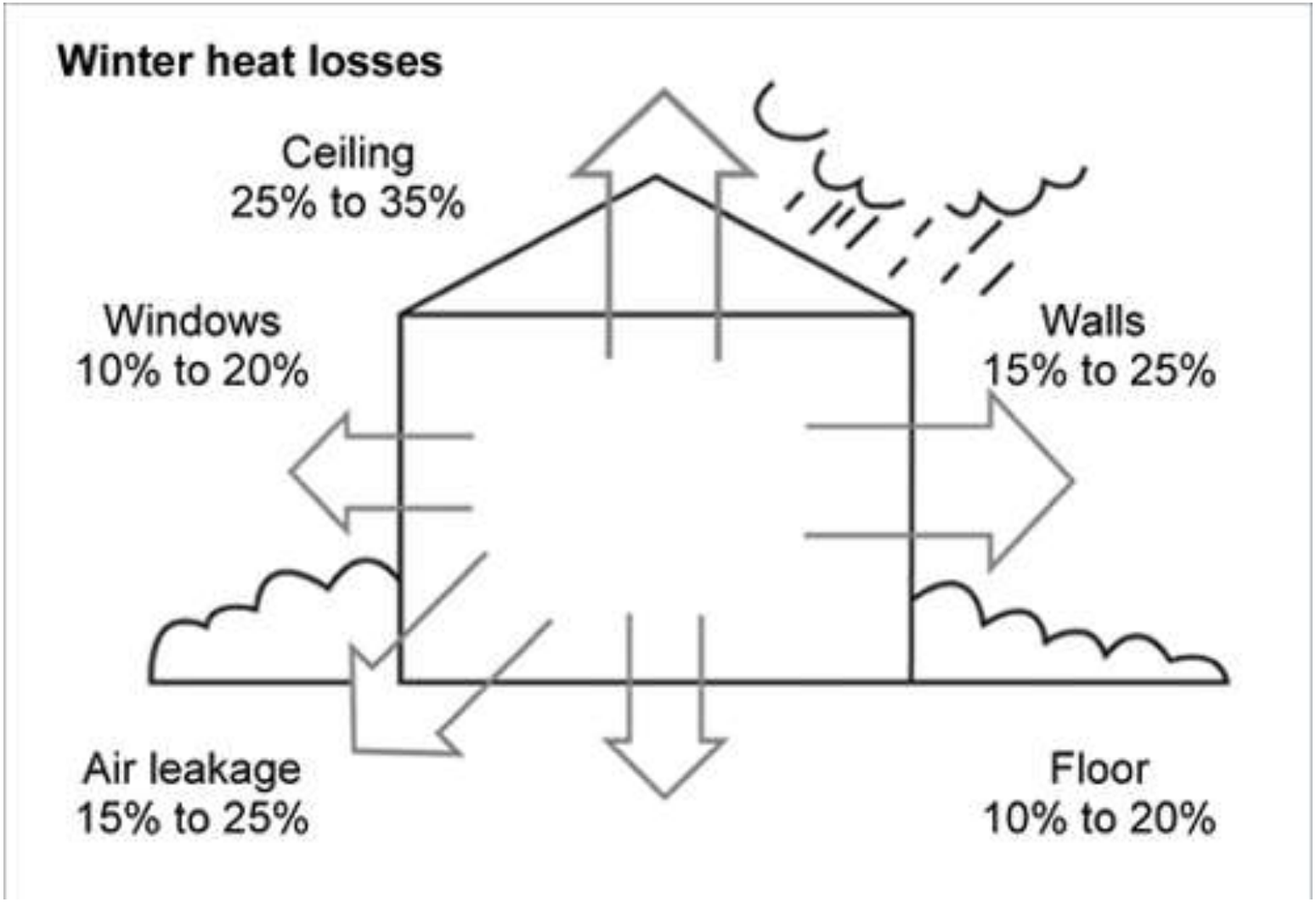
15% in temperate climates and 25% in cold climates of the area of exposed thermal mass in a room.

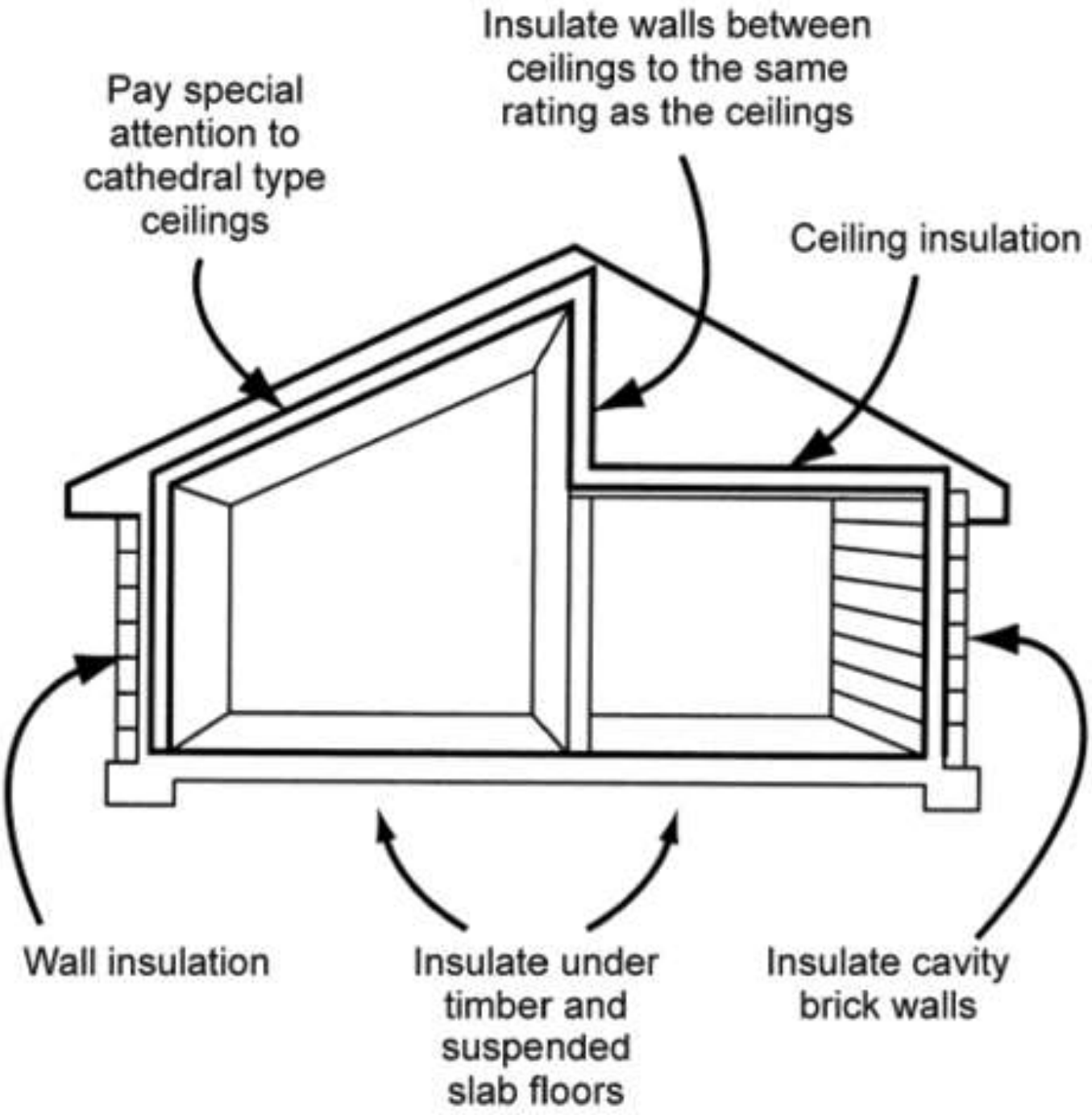
- Double glazing is highly desirable in cool and cold climates.

- Double glazing glass prevent loss of heat.

5. Preventing Heat Loss

- The building fabric must retain energy collected during the day for up to 16 hours and considerably longer in cloudy weather.
- Ineffective if the heat is allowed to escape via the passage of air or heat moving from a warm surface to a cold one.
- Close up as many openings (Windows and Doors) as you can. Windows can be a significant source of heat loss in your home.
- Ceiling insulation prevent loss of heat.
- This maximizes winter heat gain, minimizes winter heat loss and concentrates heating where it is most needed.


Winter heat losses
Ceiling
25% to 35%
Windows
10% to 20%
Walls
15% to 25%
Air leakage
15% to 25%
Floor
10% to 20%

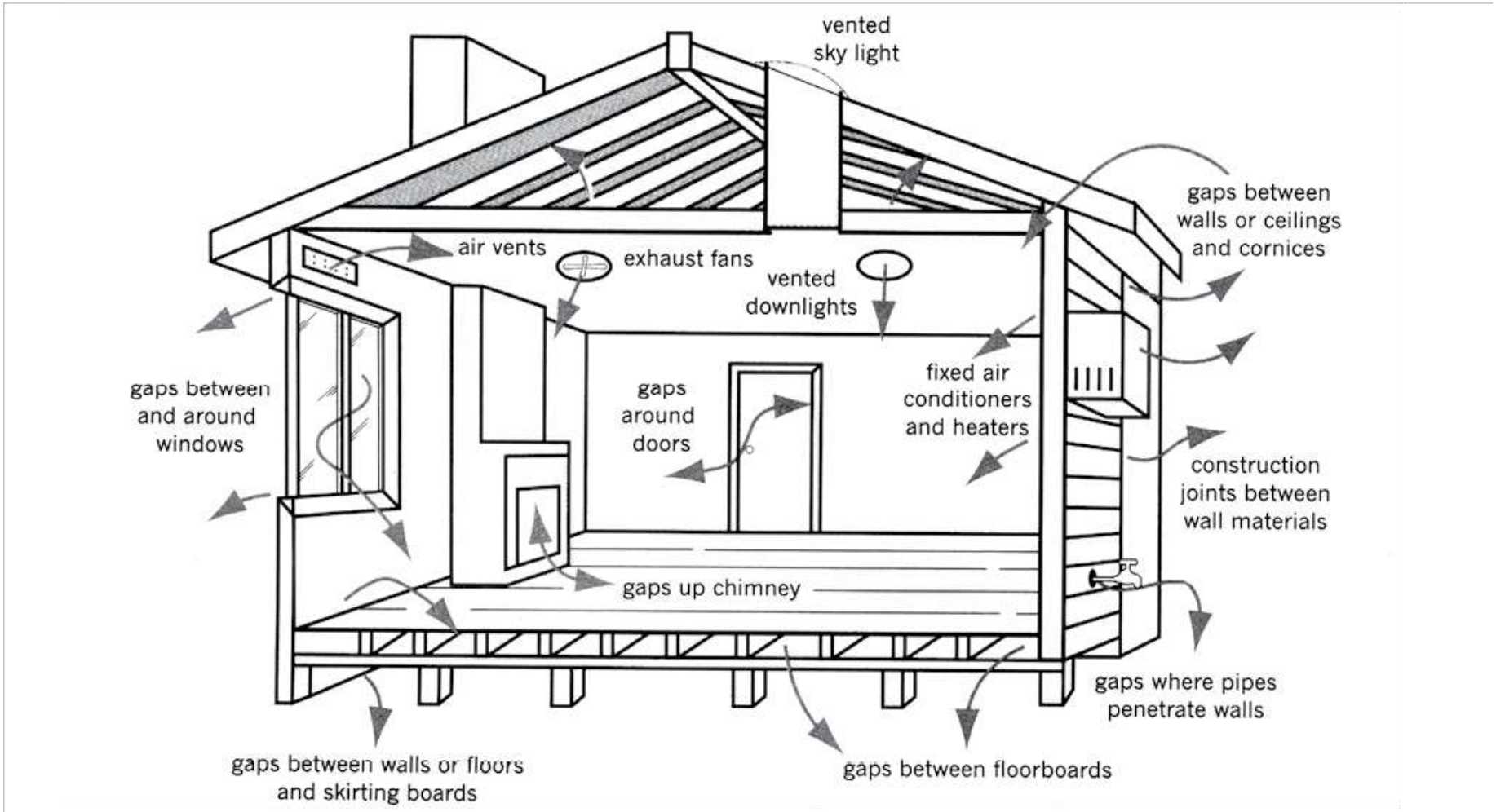

Insulate walls between ceilings to the same rating as the ceilings
Pay special attention to cathedral type ceilings
Ceiling insulation
Wall insulation
Insulate under timber and suspended slab floors
Insulate cavity brick walls

6. Draught Sealing

A current of cool air in a room

Sources of air leakage

stop cold air coming in and prevent warm air from escaping, using things like **draught** excluders. Air leakage accounts for 15–25% of winter heat loss in buildings

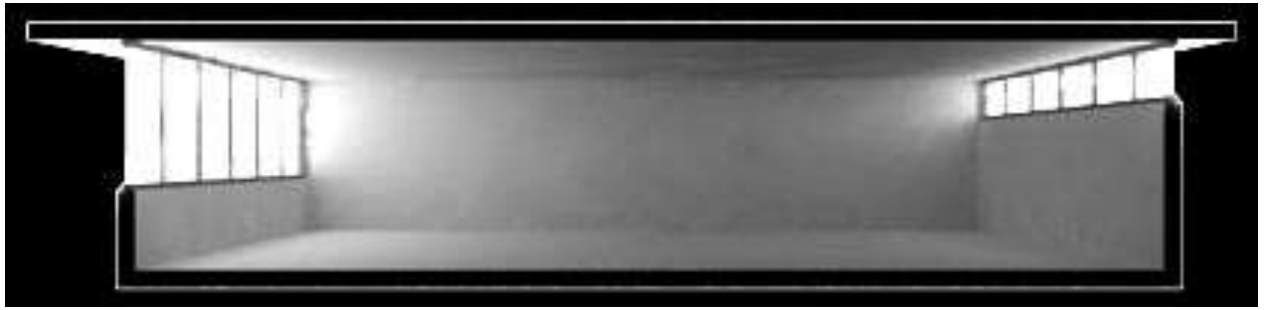


7. Zoning

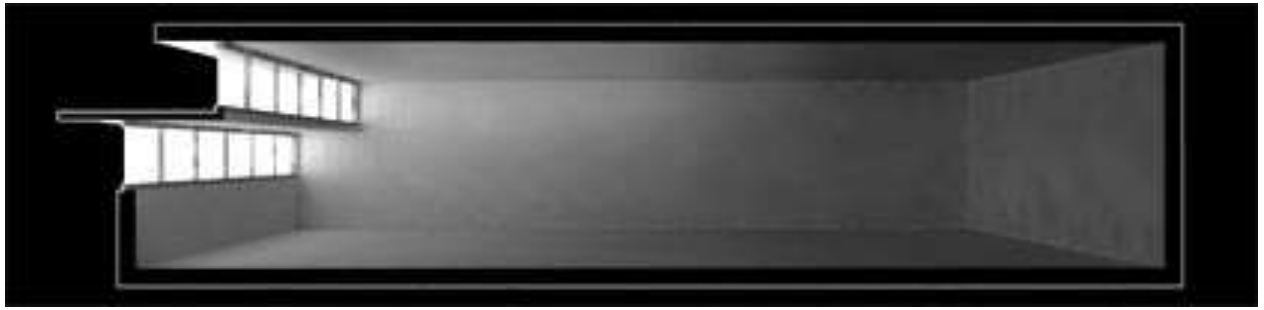
- Living areas and the kitchen are usually the most important locations for passive heating as they are used day and evening. Bedrooms generally require less heating.
- Bathrooms, laundries and garages are used for shorter periods, require smaller windows and generally require less heating.
- Should be located to the west or south-west, to act as a buffer to hot afternoon sun and the cold westerly winds **OR** to the east and south-east, except where this is the direction of cooling breezes.
- Detached garages to the east and west provide shade from summer sun and direct cooling breezes into living spaces.
- Compact floor plans minimize external wall and roof area, thereby reducing heat loss and construction cost.

Natural Lighting

Window



Windows both sides



Light shelf

Skylight

Roof monitor

Sawtooth

Light well

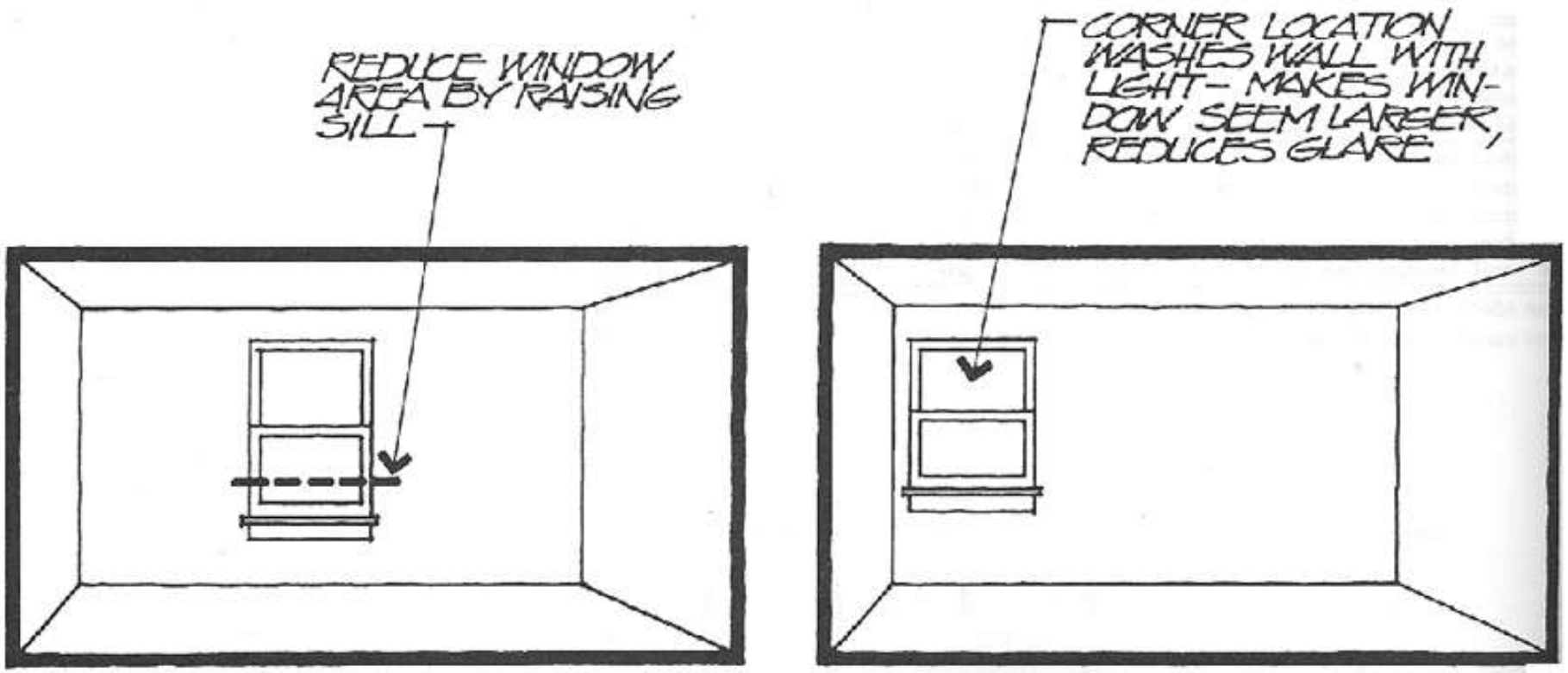
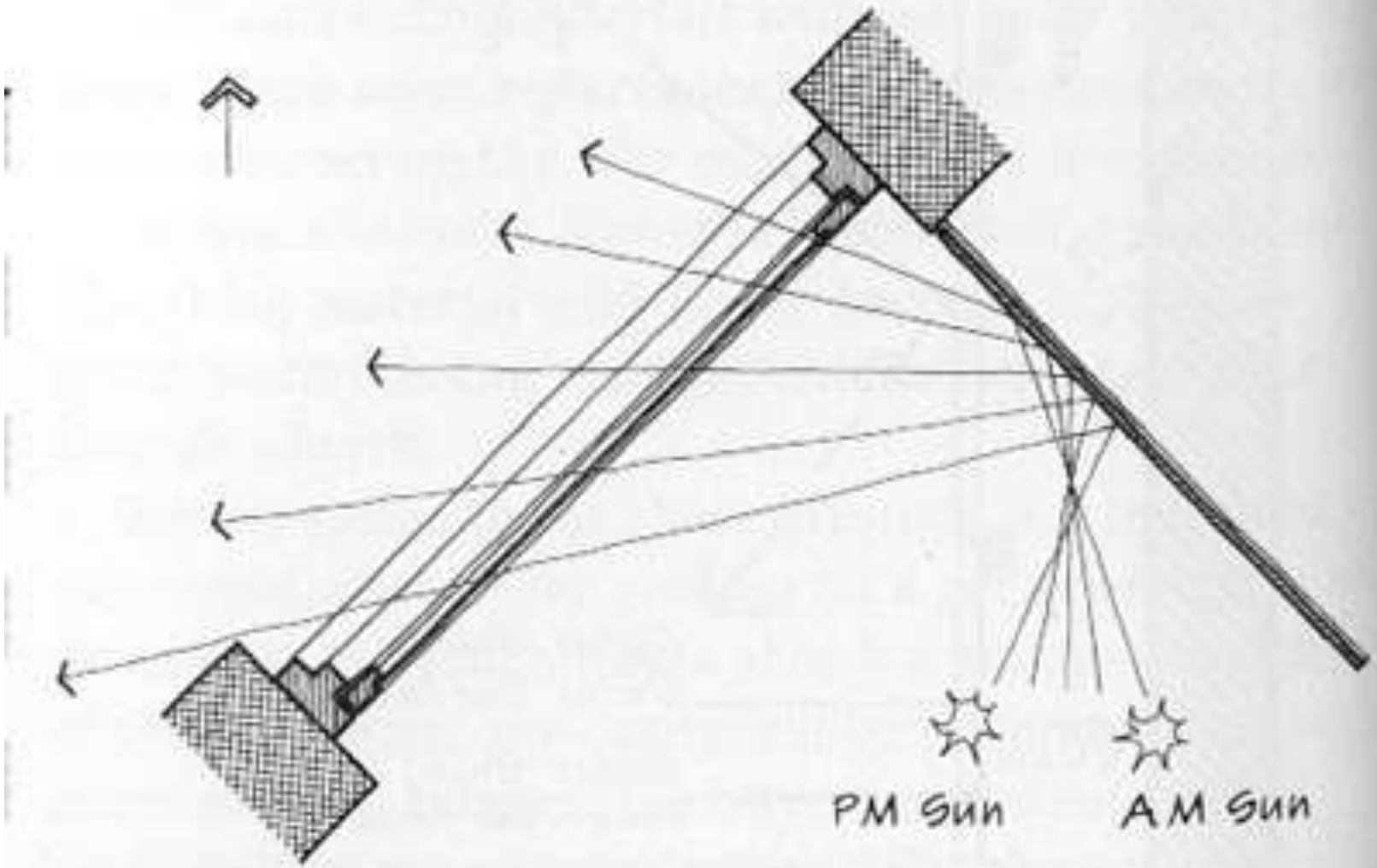


FIG. 40b. **When windows must be placed in north, west and east walls, keep the opening small, and use internal placement to best advantage.**



Plan View, Vertical Reflector for a Southeast-Facing Window
(northeast-facing in the Southern Hemisphere)